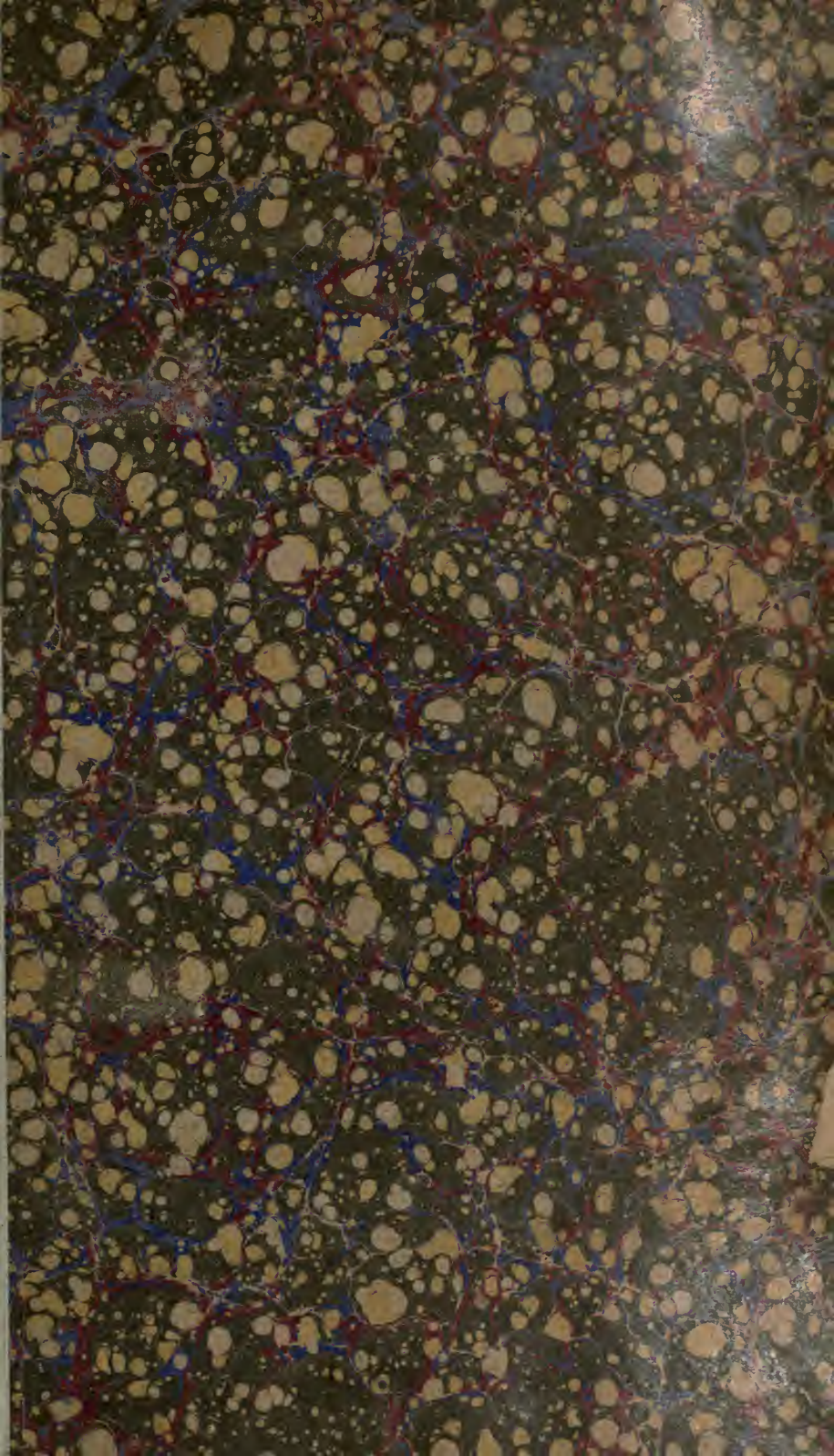





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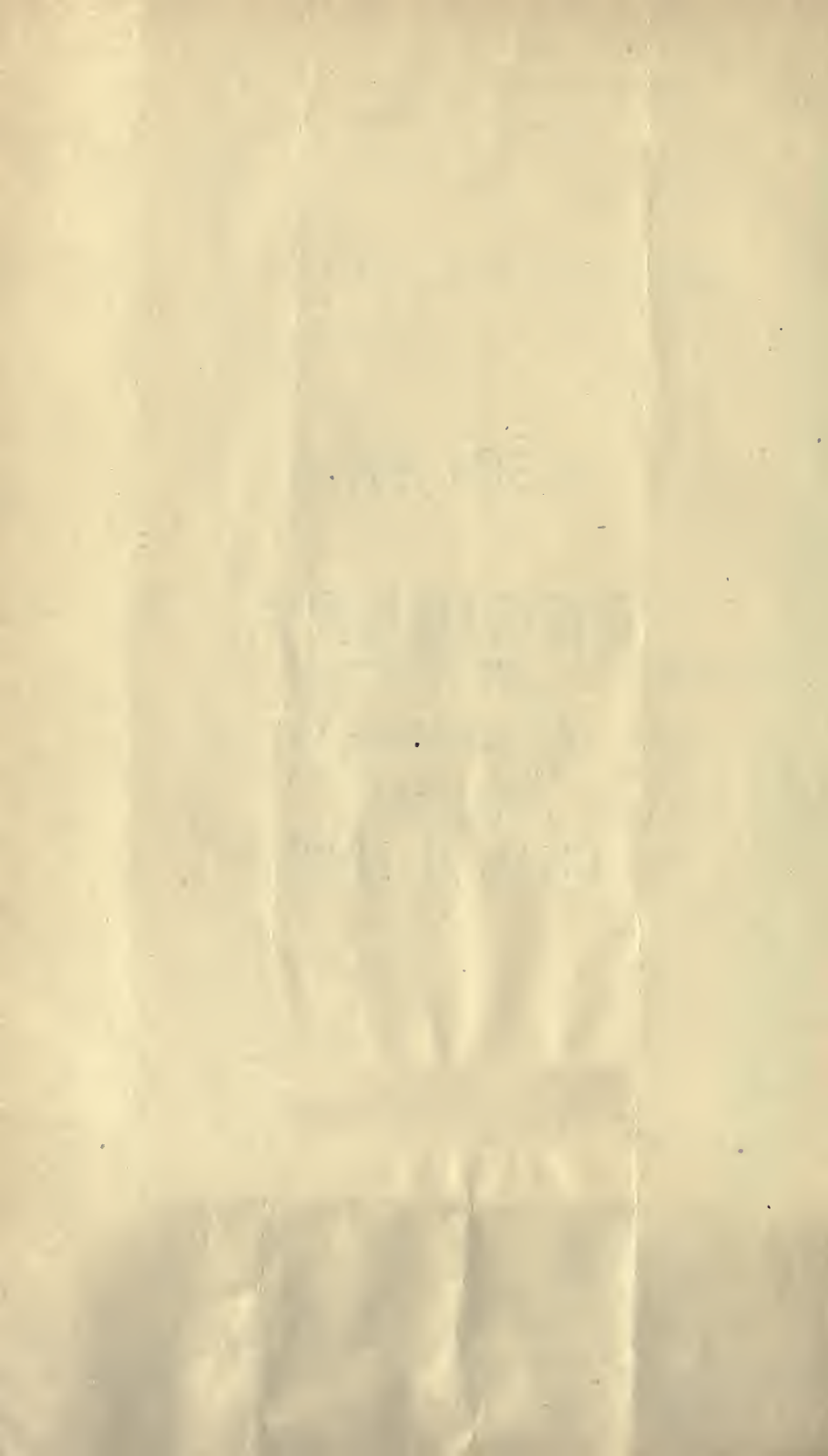
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❁ SOLAR ❁
ENGINEERY.



CHAS. H. POPE.

Farmington, Maine, U. S. A.



SOLAR ENGINERY.

An Open Field for Practical Operations.

[Deferred Paper.]

The day has come when men of hard sense and purely business habits may take up this subject, with no danger of being called visionary. The use of sun-heat is to-day exactly where the art of steam-enginery was on that October morning when Fulton set sail up the Hudson, in the year '807. Scientific men have gone over the whole ground of the principles involved and the lines in which the solar force may be used. A respectable number of experimenters have covered a very wide range of methods and applications; and a small number have sought government protection for their investigations in the art. The region in our own country where peculiar demand exists for solar engines and stoves is extensively opened by railroads; and untold wealth of gold and silver and other valuable minerals awaits the application of this least expensive of all motors; while millions of square miles of land, now practically desert, will yield as much grain as all our country now produces, so soon as settlers may procure

Engines Which Need No Fuel

with which to pump water for irrigation, and stoves, as cheaply run for domestic use.

The area of California, Arizona, Nevada, Utah, Wyoming and New Mexico, is 710,000 square miles, equal to that of all the United States east of the Mississippi river, except Wisconsin and Michigan. The overwhelming majority of those miles are destitute of trees or shrubs of any size, because of their exposure to clear sunlight three-quarters of the days of the year. Several belts of precious metals cross them, the larger part of which are undeveloped to-day for lack of wood or coal for the fuel of hoisting or pumping or reducing works. All their land accessible to coal fields, or forest-belts or watered by sufficient rain to support vegetation the entire year, is more than offset by "desert lands" within the limits of

Oregon, Idaho, Dakota and Colorado; so that the measure given above fairly represents *the region which has too much sunshine*. Yet water for irrigation is within easy pumping reach, and even alkali deserts have been found fertile; while even those valleys now producing great harvests will multiply their production greatly under irrigation. And the sun's force is the hope of all that Western world.

And the business men who now manufacture or sell steam engines, pumps, stoves and similar articles to customers thousands of miles away, need not hesitate to put brains and capital into this new line of goods. An immense market will fairly devour them as quickly as convenient machines are offered for sale.

In the present article the writer proposes to go over the history of this subject in a way to help those who have no time for the reading of many books or the search of scientific or patent records.

In 1874, the writer gave the spare minutes of a busy professional life to studies in the reflection and refraction of heat. With a set of burning glasses from $2\frac{1}{4}$ inches to $8\frac{3}{8}$ inches in diameter, he burned paper, wood and coal, melted antimony glance and zinc plate; carefully noting, among other things, the size of the spot (focal ring) over which a given degree of heat could be produced; the largest lens mentioned burning out a disc of paper as large as a dollar, at a flash. Then turning to reflectors, he was struck by the perfection with which the light of a lamp is reflected in parallel lines by locomotive headlights. "What will fetch will carry," thought he. So he borrowed one of these reflectors, set it up on a rude frame in his back yard; placed a tube of galvanized iron plate in the place made for the lamp; and had the delight of seeing a quart of water boil in five minutes, solely by solar heat! Following out this lead, with numerous other experiments, he reached certain conclusions of a practical sort as to apparatus for utilizing the heat of the sun for mechanical and domestic purposes, and in April, 1875, filed a caveat to protect his work; but on further investigation he found that a great deal had already been done in this direction of which he had been ignorant,—disgracetrully ignorant perhaps,—and that two things were demanded, at that stage of the art, neither of which he possessed; namely, mechanical skill and capital. So he abandoned all expectation in the patent line, contenting himself

with general study of the subject; and now for the first time offers to the public an appeal for this pair of requisites, on the ground that *the field is fully ripe*.

The first theorist on

Solarics,

(a term the writer ventures to coin to describe the subject of the utilization of solar heat), appears to have been the famous mathematician, Euclid; the first practical experimenter, so far as known, the learned King Archimedes, who set fire to a fleet of Roman ships, which lay in the harbor of Syracuse, by concentrating sunlight on their tarred wood and rigging. Hero, De-Cause, Sanssure, Evans, Poillet and Melloni followed on in the centuries, with what special results we do not learn. But in 1747 the renowned naturalist, Buffon, made a valuable series of experiments to prove that Archimedes *could* have done what the Latin historian, Livy, had recorded of him.

He built a large framework on which he hung pieces of silvered glass, whose reflections were all turned on a given point. Then he varied the number of mirrors and the distances of the things to be burned, and the combustibles themselves and reached the following results:

With 17 mirrors at 20 feet, he heated thin pieces of silver and iron to redness.

With 45 mirrors at 20 feet, he melted a pewter flask of 6 pounds weight.

With 128 mirrors at 150 feet, he burned a tarred plank.

With 154 mirrors at 150 feet he made a tarred plank smoke in two minutes, when the sky was obscured.

With 154 mirrors at 250 feet, he burned chips of wood covered with charcoal and sulphur.

He afterward formed a spherical burning mirror having a diameter of forty-six inches, with which he performed other wonderful experiments. In 1764 B. F. Belidor published the results of some investigations of his on the subject of solar heat, at Amsterdam, without materially advancing the matter, however. In 1838 Sir John Herschell gave his attention to this subject, and at the Cape of Good Hope proved for himself and those who read his testimony, that there is a tremendous energy in the sun's rays which man may appropriate for his uses.

I have not been able to discover any applica-

tion for a patent on any sort of sun-utilizing machine earlier than the year 1854, when, in London Antoine Poncon thus announces his claim: "My invention consists in using the sun's rays to create a vacuum in a suitable vessel, elevated at the height of a column of water; which, in the above vacuum, is kept in equilibrium by the pressure of the atmosphere. Such vacuum being formed, I fill it with water acted upon by the external pressure of the atmosphere, and thus obtain a head of water which may be applied as a motive power." Unfortunately one can learn nothing more of this *first patentee in solarics*; but his registered wisdom is very suggestive for others, it cannot, however, be said that he offers any *practical* solution of the problem. In a similar way, the patent records of England present us with *discourses* on the utilizing of the sun's heat, in the certificates of McIvor in 1865, and of Colborne and St. George a little later. McIvor's patent is chiefly on the subject of storing up the force of the concussion of ships, railway cars, surf, etc., through the use of coiled springs; but he put on record this glowing sentiment: "Although steam is a wonderful power, * * * yet at some future day it will be looked upon as insignificant compared with the stupendous powers which nature has placed at our disposal, free of cost, and

Inviting Our Appropriation.

For example, the sun, whose heat, concentrated by powerful lenses revolving by clock-work so as to be constantly in focus," will do mighty things for man; and to show how wide the scope of this force is, he mentions that on the line of the Madras railroad, where he was then stationed, in employ of the British government, "on the average we have two hundred and eighty bright days in a year; when the unconcentrated heat of the sun is all the way from 120° to 160° Fahrenheit," (a statement, by the way, which suggests California, Arizona, Nevada and New Mexico.) But five years before Captain McIvor had filed this paper in England, namely in 1860, a Professor of mathematics in the Lycee d'Alencon at Tours in France had

Actually Invented

a solar machine, and made practical use of his discoveries. Without gaining—or seeking—the attention of the general public or of the business world, he pursued his experiments for several

years, aided by the government to some degree, from regard to the prospect that sun-engines might bring great wealth out of Algeria.

In 1871 the French patent records show the mark of this inventor, the first in this department (associating it with philosophical and kindred apparatus, "Instruments de précision.") In '72 Mouchot filed an additional certificate in which he shows more fully the plan he has since perfected; and in 1875 he obtained a third patent, under which he is now operating. In '77 he also obtained an English patent, covering the same ground.

He has never applied for a patent under our laws. The great conical reflector which he first erected in the court yard of the Library at Tours in May, 1875, he afterward exhibited at the World's Fair in Paris in 1878, where thousands looked on with astonishment while they saw a steady stream of water pouring forth from a pump whose only motor was a bundle of sunbeams! and since that time he has constructed a number of other machines which are now used in Algeria, raising water from wells in the deserts, for irrigation and for domestic purposes.

It must be acknowledged that

Augustin Bernard Mouchot

is to be ranked with Watt, Stephenson, Fulton, Morse, Bell, and their like; as one of those notable benefactors of mankind, who have, at great pains, brought grand forces and processes *out of the empirical into the practical stage*. After all due honor has been given to the ancient and modern experimenters in *solar science*, Mouchot deserves credit as having first established the

Art of Solar Enginery;

bringing the sun, as a motive power within easy reach of the working world. Although his particular ways of reflecting and applying the force of the sun's rays may not prove the best; though Yankee ingenuity may some day make machines as far superior to his as the latest trans-Atlantic steamship is to that in which Fulton made his first voyage; still he is the world's benefactor in the way I have stated; but no one can estimate to-day the magnificence of the New World into which this greater than Columbus has led us.

Meanwhile on this side of the Atlantic, a few persons had been at work, none, however, with

anything like M. Mouchot's singleness of purpose and untiring persistence.

Capt. John Ericsson, that great mechanic whom Sweden gave us, [appendix A] constructed engines of five-inch cylinder and six inch stroke, running them at a speed as high as three hundred revolutions a minute with sun power; using in some cases air and in others steam, at a temperature of 480° . His studies and discoveries in the use of hot air as a motor, kept him alive to the value of the sun as a producer of energy. He stated that the heat concentrated from one hundred square feet of surface would evaporate 489 inches of water; more than equivalent to one horse-power. But the writer has been unable to find any date or description of the method of the experiments he made, or the record of any patent he took out under this topic of solar heat. Yet he contributed greatly to the interest of the scientific world by his expressions of interest in it, and his predictions of its immense employment in the near future.

The earliest patent given by our government for invention in this department, runs to John S. Hittell and G. W. Deitzler of San Francisco, California, under date of March 20th, 1877.

On the 27th of April, 1880, the second United States patent for a "Solar Heater" was obtained by James P. Mauzey of Blackfoot, Montana, and May 19th, 1882, Mr. Deitzler took out an additional patent, covering some points in advance of his former one (with Mr. Hittell).

San Francisco parties have also sought British protection; Eusebius J. Molera and John C. Cebrian having obtained a patent Oct. 22d, 1880, for "Boilers, condensers and apparatus connected therewith, for utilizing the heat contained in solar rays, thermal springs, mines, or the like." [Appendix D.]

We thus have eleven patents running to ten individuals, four patents being upon the works of one man, M. Mouchot; four others to as many firms or individuals; and three which are not strictly inventions, but ought rather to be grouped with that caveat of which mention was made above as

Announcement of Plans to Invent.

In addition to these persons there is one who deserves very honorable mention—Mr. W. Adams of Bombay, India, who communicated to the *Scientific American* (June 15th, 1878,) a spir-

ited account of some most practical things he had done in the use of solar heat as a cooking agent.

How many others have helped forward this work *quien sabe*? As the writer has never had the honor of personal acquaintance or correspondence with a single individual who has given it critical attention, and has had but limited opportunity of reading the class of publications which might naturally chronicle such labors, he can claim to offer no complete history or analysis of the topic, but a contribution to the subject; which may help any who desire to work in this department, and may draw out much more valuable offerings from those better qualified. [Appendix C.]

How, now, can the heat of the sun be captured? Molera and Cebrian say: "Take it as it comes;" and they put all their skill into the construction of boilers consisting essentially of two parallel shells, suitably connected, and having between them a narrow space which is filled with the liquid to be vaporized and to drive the engines. They are placed horizontally, and *do not require to be changed in their position* according to the daily movement of the earth * * * As they expose a large surface to the source of heat * * * the generation of the vapor is very rapid. "Similar vessels are used for the condensation of the vapor, the temperature being reduced by the use of snow or ice."

But other inventors feel the necessity of some process which will bring the rays of the sun more or less perfectly to a focus. A flat mirror, slanted a little, gives a line or patch of heat. Perhaps Archimedes burned the Roman fleet by stationing many groups of men along the shore, holding up huge plates of polished brass, each of which sent its hot mass of reflected rays against the common mark. Buffon used numerous flat pieces arranged on a framework, such that one person could move it all together and concentrate their force. Mauzey, in this way, grouped mirrors of curved forms into one complex reflector. [Appendix D.] Mouchot first employed a number of concave mirrors for producing heat sufficient for mechanical purposes; but later adopted the truncated cone with which his great successes have been reached. In the centre of this cone he erects a bell-glass, under which he places a copper boiler of similar form, whose outer surface is blackened. This boiler

is double-walled and has tubes which bring in water and carry out the steam through the bottom of the reflector, to be used as in common steam engines. A system of cog-and-screw gearing is used to keep the reflector facing the sun all the day. Hittell and Deitzler show a slightly concave *mirror* with which they throw focalized heat "upon a mass of iron or other suitable material" "as a reservoir of the heat;" "a reservoir chamber, a heat-box, a drying chamber, and a devaporizing chamber," letting cold air pass in and then pass out after the sun has heated it; applying it then to ordinary hot-air machinery. Deitzler, in his second patent, proposes a reflecting mirror, straight one way, curved the other,—half of a tube or cylinder, if you please; and in the hot line-focus, thus formed, he places a tube filled with the material to be heated. He uses the common methods to keep the reflector facing the sun. Mr. Adams arranged one hundred and ninety-eight panes of glass, silvered on one side, in a framework, and placed a boiler, containing nine gallons of cold water, at the focus, twenty feet away. In thirty minutes it began to boil; after one hour's boiling he found that three and a half gallons had evaporated. He afterward made a reflector somewhat like Mouchot's,—six-sided instead of circular,—and in an enclosed boiler cooked various articles. "The rations of seven soldiers, consisting of meat and vegetables, cooked thoroughly in two hours;" and throwing a rug over the apparatus all kept hot for hours. A leg of mutton was perfectly cooked in it, and kept piping hot two hours by similar covering.

Perhaps burning-glasses, double convex lenses, may have practical value for the purpose we are considering; wonderful things have been done with them in experiments. But as they focalize the rays only on one side of the object to be heated, while reflectors may concentrate heat on several or all sides of it; a decided preference has been shown for the reflectors, by all who have produced truly practical results. Yet in the infancy of the art no one can safely dogmatize against any of the methods by which philosophers have brought solar heat into service.

Another practical question is

How Large May Solar Engines Be Made ?

The head-light reflector spoken of was twenty-one inches in diameter and of the same depth;

Mouchot's truncated cone exhibited at Paris was one hundred and twelve inches in diameter and thirty-six inches deep, having an area of forty-five square feet. Ericsson considers every one hundred feet of sunshine capable of yielding one horse-power; an estimate which was made in the humid climate of an Atlantic State, and which takes no account of the greater heat of the sun in regions further south or having a drier climate, nor of the *accumulation* of heat when reflected through successive hours. But at that rate we should have reflectors of circular base, having 11.3 feet diameter, give 1 horse-power: 16 feet, 2 horse-power; 19.4 feet, 3 horse-power; 22.7 feet, 4 horse-power; 25.33 feet, 5 horse-power; 35.4 feet, 10 horse-power; 50 feet, 20 horse-power.

Of course much judgment and skill will have to be used in balancing and bracing and revolving reflectors, in the windy regions where their largest use must be; but it need not be very costly to do all that. The material must be carefully studied; pure silver plating being the finest reflecting surface, and lime or gypsum "white-wash" having surprising value for the purpose; with a great range of substances between them. Whether to surround the reflector with non-conducting substances, like asbestos felting; whether to cover the mouth of the reflector with glass, to keep in its gathered heat; whether to erect separate reflectors (along a hillside or otherwise) and converge their force on one spot, simple provisions like Mons. Mouchot's guarding the central boiler from any loss of what it thus receives; and what form is best for *the receiver itself, in which the heat is to become a motor*: to these points practical sense must be brought, and hundreds of good methods will doubtless be found.

The government may profitably use numbers of solar furnaces at its military garrisons and Indian reservations; the trans-continental railroad companies, also, may employ many of them for their stations, and greatly increase the value of their lands by developing this motor.

That which has made deserts may become the very means of reclaiming them; and in regions where the sky is clear only a minority of the days of the year, sunshine may be used as an occasional auxiliary for many purposes. Considering the rapid diminishing of our forests and the tremendous drafts now making on our coal fields, we ought to lose no time in availing

ourselves of this most freely offered and cheaply available resource; since it has been absolutely proved that it is wholly practicable, and wants only the touch of that manufacturing energy which distinguishes our country.

CHARLES H. POPE.

Farmington, March 22d, 1883.

APPENDIX A.—Ericsson demonstrated that the heat of the sun, shining on a square mile of surface, gives power enough to drive 64,800 engines, each of a hundred horse-power; using only one-half of the surface for gathering the heat, and devoting the remainder to buildings, roads, etc.

APPENDIX B.—During his early investigations, Mouchot brought out what he called a "*Marmite Solaire*." In its best form, this was a conical mirror of silver-plated brass; at its focus a glass dish, with cover of the same, in which articles to be cooked were placed—vegetables, fruits, meats and other things—were successfully cooked in these "marmites," wholly by the concentrated heat of the sun. For example, a kilogramme loaf of bread, placed on a disk of iron, and enclosed in the glass dish, baked thoroughly in less than three hours.

APPENDIX C.—As an English writer on invention has said: "The most talented man can make but little progress when left to his own individual exertions. By bestowing some time upon the study of the labors of others, he may combine a little more science with his great mechanical abilities, and thereby be more likely to prosper in his designs."

APPENDIX D.—Mr. Hittell has attracted considerable attention by his volume on the "Resources of California;" by a magazine article on the "Apotheosis of Steam." Of the other American patentees the writer has no knowledge.

NOTE.—For those who have taste and leisure for such labor, the following list of works to be consulted is given: Knight's American Mechanical Dictionary, Appleton's Cyclopaedia of Applied Mechanics, Rose's Biographical Dictionary under Buffon, *Le Revue des Deux Mondes*, May, 1876, *L'Emploi Industriel de La Chaleur Soirire*, par M. L. Simomin, [Translation of the same in *Pop. Sc. Monthly* Vol. 17, page 555] *The Scientific American* of July 14th, 1877, of June 15th, '78, and of Feb. — 1883. [*Eccl. Engin.* Vols. 3, 4, and 10]; French Patent records for 1871 and 1875; British Patent records for 1854, 1865, 1877 and 1880; U. S. Patent records for 1877, 1880, and 1882. It is possible that German and foreign Patent records might furnish important matter, but there are no index helps to shorten the searcher's labor, so the writer has no knowledge of them. Perhaps other books and papers contain valuable items for this subject, such as reports of philosophical bodies or industrial expositions, illustrated journals, etc. etc. No bibliography of the subject has hitherto been attempted, so far as the writer knows.

